Forintek Canada Corp.

ISSN 0708-6172

Stellite Tipping of Saws for Cutting Softwood Lumber

E. Kirbach & T. Bonac

Western Laboratory

Technical Report No.17

Forintek Canada Corp., with laboratories in Ottawa and Vancouver, is a private, non-profit corporation. Its laboratories have unrivalled reputations as centers of excellence in research and development for the wood products sector of the forest industry.

Forintek's professional and support staff of 250 is actively engaged in basic and applied research in all the major scientific and technical disciplines related to wood products.

These include: sawmilling, seasoning, machining, composite products, adhesives, timber engineering, wood preservation, and the wood sciences. Forintek is a problem-oriented organization that offers expert advice to the forest products industry, professional associations, consultants, provincial and federal government agencies, trade associations, equipment manufacturers, educational institutions and the general public. These services are offered with the objective of realizing the optimum benefit from one of the country's most important natural resources - the forests.

STELLITE TIPPING OF SAWS FOR CUTTING SOFTWOOD LUMBER

BY

E. KIRBACH & T. BONAC

TECHNICAL REPORT
NO. 17

PRESENTED AT "LUMBER MANUFACTURING UPDATE" SEMINAR
OCTOBER 26-28, 1981, SEATTLE, WA

FORINTEK CANADA CORP.
WESTERN LABORATORY
6620 N.W. MARINE DRIVE
VANCOUVER, BRITISH COLUMBIA
V6T 1X2

AUGUST, 1981

Reissued August 1982

ABSTRACT

The report presents the results of two studies. The first study investigated the effectiveness of four wear-resistant alloys - Stellite 12 and 20, Deloro Alloy 50 and 60 - in reducing saw-tooth dulling in cutting unseasoned western red cedar. All four alloys substantially reduced dulling. The best results were obtained with Stellite 12. In comparison to standard steel saws the saws tipped with Stellite 12 showed at least 12 times less dulling.

The second study compared the cutting performance of stellite (Stellite 12) with two cemented tungsten carbides and standard saw steel in cutting unseasoned western red cedar, western hemlock and white spruce. The stellite outperformed the two tungsten carbide grades significantly which suggests that carbide-tipped saws may be replaced with stellite-tipped saws, in particular in thin-kerf sawing operations.

The stellite-tipping technology, the benefits of stellite-tipping and the equipment costs for stellite tipping and maintenance of stellite-tipped saws are briefly discussed.

INTRODUCTION

Tool wear profoundly affects both lumber yield and manufacturing costs. The manner this problem is dealt with may determine whether many mills remain competitive.

Wear or dulling increases consumption of power by as much as 15%, doubles surface roughness of cut lumber, reduces cutting accuracy, reduces the quality of chips, and causes down-time and high costs for maintenance and replacement of cutting tools.

In most sawmilling operations where wet wood is cut, wear involves two components, an abrasive and a chemical component. Abrasion removes material mechanically. Chemical wear involves reaction of wood extractives with the cutting tool, generating water soluble reaction compounds which are then lost. Figure 1 shows schematically a steel tooth and a tungsten carbide tip in the sharp and dull state. A stellite tip looks essentially like the steel tooth.

In the past, many attempts have been made to prolong the sharpness of cutting tools used in wood machining operations. Some of the methods have been successful and are being used in various areas of wood cutting. Of these, probably the most widely used material is cemented tungsten carbide. In sawmilling, approximately 30% of the circular ripsaws are now carbide tipped. Table 1 shows the methods which have been tested in sawmill cutting operations. The table also lists the principle elements which are incorporated into the more wear resistant cutting edges.

The five methods of improving the wear resistance are described in detail in a report prepared recently by the author.* This report also contains an extensive section on coping with problems encountered in operating and maintaining carbide tipped saws. The report is now used extensively in B.C. filing rooms as a reference book.

In the past, it has been considered that tungsten carbides are superior to all other practical cutting tool materials including stellite. This conclusion apparently stems from experience obtained in cutting wood and wood composite products in the dry state. This industry practice, together with the considerably higher labor input of the conventional stellite tipping process, may have been responsible for the situation that stellite tipping was applied only to band saws used in cutting extremely abrasive, tropical hardwood species.

The introduction of new stellite tipping equipment and also the need to improve the wear resistance of band saws in general, has prompted a series of studies that investigated the performance of stellite alloys in cutting wet wood. In the first study, the attempt was made to single out the most suitable stellite material and compare it with standard saw steel. In the other three subsequent studies, the best stellite material was tested against two cemented tungsten carbides in cutting western red cedar, western hemlock and white spruce. The results of all four studies are presented in a summarized form.

* E. Kirbach, 1979. Methods of improving wear resistance and maintenance of saw teeth. Technical Report No. 3. Forintek Canada Corp., 6620 N.W. Marine Drive, Vancouver, B.C.

TESTS AND RESULTS

Experiments with Two Stellite and Two Nickel-Based Wear Resistant Alloys

Experimental

Stellite is not one particular alloy, but a series of alloys containing cobalt as a major element. Depending on the metal composition, these alloys vary greatly in mechanical properties, and consequently, also in wear resistance. An analogous series of alloys containing nickel as the major metal show a similar range of properties as the stellite series. From each of the two series, two alloys which appeared to be most suitable for sawing applications, were tested. The chemical composition of the four alloys, together with their hardness, are shown in Table 2. One of the chosen alloys, known as Stellite 12, is the material which has been used most widely in the past for stellite tipping of saws.

All four materials are highly resistant to both abrasive and chemical (corrosive) wear. Further, they show superior ductility to cemented tungsten carbide grades used for sawing applications, have a low coefficient of friction, show no loss in hardness when heated to high temperatures, and can be ground with wheels that are used for grinding high-speed steel.

The wear resistance of the four alloys and the standard saw steel were tested with circular saws cutting unseasoned western red cedar, in the sawmill and in the laboratory. The laboratory data provided the more accurate comparison between the tool materials because the amount of wood sawn could be determined exactly and it also could be ensured that the teeth of each tooth material cut the same type of wood material and that no foreign objects, such as small rocks or sand were present.

The wear of the tips or teeth was measured by photomicroscopy. Negative edge profiles as shown in Figure 2 were obtained and the edge retreat was measured as shown in Figure 3.

Results

Results of the tests are presented in Figure 4, which shows the change in cutting edge retreat with length of cutting path. The saw steel teeth and the wear resistant tips dull at vastly different rates. Between Stellite 12 and the standard saw teeth, the difference in cutting edge retreat after 35 km of sawing, which corresponds closely to four hours of sawing in the mill, is about 12 times.

Most of the difference between the saw steel and the wear resistant alloys occurred near the beginning of cut, i.e., from 0 to 10 km. After 35 km sawing the dullness of the Stellite 12 tips is equivalent to the dullness of the standard saw teeth after about 1 km or 6 min. The curve for the saw steel clearly shows that the standard saw teeth are seriously dull after only 60 minutes of cutting. Unfortunately, it is common sawmilling practice to keep saws in operation for two or more hours after they exceed this level of dullness, in order to avoid down-time. Thus much cutting is performed with a dull saw which produces lumber of a high degree of roughness and, in the case of thinner saws, of considerable thickness variation. It is a well known fact that roughness and cutting accuracy are influenced by dulling.

Figure 4 also illustrates that the wear resistant materials tested are not equally suited for saw tipping. The two nickel containing alloys - Deloro Alloy 50 and 60 - showed significantly duller cutting edges than Stellite 12. Stellite 20 was not tested in the laboratory, because of poor mill performance. In Figure 4, the slopes of the cutting edge-retreat curves indicate a higher rate of dulling of the two nickel alloys, which, however, accounts for only a small portion of the ob-

served difference. The primary reason is a loss in cutting edge due to breakage during grinding. When saws tipped with the two nickel alloys and Stellite 20 were ground on a standard wheel, the materials were not sufficiently ductile to withstand the pressure of the grinding wheel along the very tip of the cutting edge. Using a wheel with finer grit probably would have reduced or even eliminated edge breakage.

In conclusion, all four wear resistant materials drastically reduce saw tooth wear, but only Stellite 12 should be used for saw applications because of its superior grinding properties. It produces a tip of superior, initial sharpness which affects the condition of the cutting edge during the total length of the cutting period.

Experiments Comparing Stellite and Tungsten Carbide Tipped Saws

The excellent performance of the Stellite 12 alloy in reducing saw tooth wear prompted a study in which Stellite 12 was compared with cemented carbides used for saw tipping. Initially, this study was limited to cutting western red cedar, but was extended to include two more species - western hemlock and white spruce.

Experimental

All tests were carried out with a special laboratory saw setup. The circular saw carried only one tip, either stellite, carbide, or steel. The use of only one tooth on the saw reduced the amount of wood to be cut to manageable amounts, despite extended operating times. Special care was exercised to ensure that the cants were extremely clean and free of any foreign objects, such as sand grains, which could interfere with the dulling process.

Two carbide grades were included in the experiment. One grade, containing 6% cobalt is the standard grade used in sawmilling. The other grade approximates the grade used for carbide saws with large hook angles (up to 45° hook angle); advocated to reduce power consumption.

The stellite tips were welded onto the saw and the carbide tips were brazed. Tip geometry was the same for both materials. The hook angle measured 30° and the clearance angle 7°.

Tooth sharpness or dullness was measured as in the first study. The 80 km of cutting which were performed corresponds to 7 to 8 hours in most sawmills.

Results

The results are presented in Figures 5 to 7 which show the cutting edge retreat - cutting path relationship for the four cutting tool materials tested and the three species.

For all species stellite (Stellite 12) showed consistently the lowest rate of wear, followed by the 6% cobalt-containing carbide grade, the 18% carbide grade and finally the saw steel. Most significant of these results is that the stellite out performed the 6% cobalt-containing carbide grade by as much as 2:1. This performance of the stellite tips was unexpected and is considerably superior to that reported in the literature, which consistently describes the wear resistance of carbide tips as being far superior to the wear resistance of stellite tips.

The superior performance of stellite was observed first in cutting red cedar. The corrosive nature of the cedar wood was deemed responsible for the higher wear rate of tungsten carbide, since the acidic compounds in the cedar wood (extractives) are known to chemically attack the cobalt matrix, which weakens the support of the tungsten carbide crystals. But, as Figures 6 and 7 show, the difference between stellite and the 6% cobalt- containing

carbide grade was even somewhat more pronounced in cutting hemlock and spruce.

The superior performance of stellite in cutting these three species suggests that it may be superior also in cutting all other unseasoned North American softwood species. So far, no tests have been undertaken to compare the performance of these two tool materials in cutting dry wood, but it is likely that in this situation, tungsten carbide shows less wear than stellite because wear in cutting dry wood is predominantly an abrasive process. Abrasion is known to be largely controlled by the hardness of the tool material. The hardness of cemented carbides (67 to 82 R_c) by far exceeds the hardness of stellite (Stellite 12, 47 to 50 R_c).

An inferior performance of the 18% cobalt-containing carbide grade, relative to the 6% cobalt-containing carbide grade, was expected. An increase in cobalt content always reduces the wear resistance of the carbide material. It is evident from Figures 5 to 7 that an increase in cobalt from 6% (content of the standard grade) to 18% profoundly reduces the wear resistance of the carbide tip.

The loss in wear resistance of the 18% cobalt-containing grade is most pronounced in cutting unseasoned red cedar. After only 10 km of cutting, this grade showed approximately the same degree of wear as the 6% cobalt-containing grade after 80 km of cutting. In cutting hemlock, the 18% cobalt grade performed somewhat better, but still after only 20 km of cutting the softer carbide grade was as dull as the harder grade after 80 km. The best performance of the 18% grade was found in cutting spruce where the difference between the two grades was surprisingly small. The softer grade showed only 25% more wear than the harder grade.

Much of the high wear resistance for which carbide tips are known is lost by using a grade with a cobalt content of as high as 18%. The difference in wear resistance between the 18% cobalt-containing carbide grade and standard saw steel after 40 km of cutting hemlock and spruce was only about 2:1. This limited improvement in wear resistance does not merit use of this grade for wood cutting applications. However, a carbide grade with an even slightly higher cobalt content - 20% - is now being applied to wood cutting saws in order to provide a carbide tipped saw which allows much larger hook angles - up to 45°. Using this hook angle is claimed to provide significant savings in power consumption, which is unquestionably true for a sharp saw. Nonetheless, the overall savings may be insignificant due to a faster dulling rate of this carbide grade.

In conclusion, in sawing unseasoned softwoods, stellite (Stellite 12) dulls much less rapidly than carbide-tipped or steel saws. Tungsten carbide grades with high cobalt contents are low in wear resistance and provide only a limited advantage over steel saws in reducing saw dulling.

STELLITE TIPPING TECHNOLOGY

The conventional method of stellite tipping was solely a manual process. For this reason it was time consuming and also required a high level of skill. The method basically involved the deposit of a round bead of stellite material onto the tip of the saw tooth using a torch and a welding rod. Heavy grinding was required to obtain the desired geometry of the tip in which approximately 50% of the deposited material had to be ground off. Furthermore, the teeth had to be swaged and shaped before tipping and old deposits had to be ground off since they interfered with swaging.

The tipping technology has changed drastically with the introduction of a semi-automatic machine. This machine still requires the use of torch and welding rod, but it shapes the de-

posit to the geometry of the tip by a molding or clamping action. Figure 8 shows the types of deposits obtained with the conventional and the new method. Other important features of the tipping process with the semi-automatic machine are: no swaging, no shaping, no grinding off of old deposits, less grinding, less stellite material, up to 20 resharpenings before retipping (compared to three with conventional tipping) and less skill for tipping.

The key part of the tipping machine is the jig which performs the tooth molding action. Besides molding the deposit, the jig also allows a better positioning of the flame and the welding rod. Figure 9 presents a schematic drawing of a jig consisting of four jaws in the open and closed position. The jaws are in the open position when the stellite material is deposited onto the tooth (Figures 10 and 11) and as soon as the material has been deposited, the jaws close quickly to perform the molding action while the stellite deposit is still soft. The jaws are shaped to give the stellite tip the desired hook, clearance and side angles.

After tipping, the saw teeth have to be tempered to eliminate chill lines that may have been formed during the tipping process. Tempering is performed by heating the saw teeth with a torch until the color of the steel turns light brown.

Figures 12 and 13 show the overall design of a commercial stellite-tipping machine for circular and band saws.

After tipping and tempering, the saw is ground. Grinding is performed on all sides: front, top and the two sides. Side grinding is mandatory which implies that a mill using band saws has to acquire a side grinder together with the tipping machine. For side grinding circular saws the mill may use a side grinder designed for carbide tipped saws or may employ the band saw side grinder with attachments for circular saws.

Tooth angles of stellite tips are identical to angles used for standard steel saws. Grinding can be performed with aluminum oxide, silicon carbide and cubic-boron-nitride (CBN) wheels. The latter wheel is probably the most economic.

It is not good practice to operate stellite-tipped saws until they are completely dull, which is common practice with standard saws. Preferably the saw should be sharpened at the time the saw needs retensioning. If the cutting period exceeds this time, the saw may develop gullet cracks. Also, surface roughness of cut lumber and deterioration of sawing accuracy can be kept at a minimum. In order to avoid downtime with standard saws a higher degree of surface roughness and deterioration of cutting accuracy must be accepted. However, with stellite tipping, this is unnecessary.

BENEFITS OF STELLITE TIPPING

In comparison to standard steel and carbide-tipped saws, stellite-tipped saws provide several substantial benefits. The benefits of stellite-tipped saws compared to standard steel saws are:

1. Extended cutting period and elimination of downtime. Downtime is eliminated in those mills where the accepted cutting period with standard steel saws, prior to saw change, is less than four hours.

2. Less surface roughness of cut lumber and less deterioration of cutting accuracy with cutting time. With stellite tipping, sawing does not need to be continued until the saw is completely dull. Reduced roughness and less deterioration in cutting accuracy in turn allows a reduction in target size with a resulting increase in lumber yield.

3. Reduced power consumption. With standard steel saws, power consumption increases on the average by

15% when the saw cuts for four hours, but the increase with a stellite-tipped saw for the same period of cutting amounts to 1.5% only.

4. Reduced saw costs. The grinding of stellite-tipped saws is essentially limited to the tips and the gullet is ground only slightly.

These benefits are obtained without significant additional labor costs. The costs of applying the tips are largely compensated by the elimination of swaging and shaping.

In comparison with carbide-tipped saws, stellite-tipped saws have the following advantages:

1. Extension of cutting period.

2. Stellite tipping is better suited for thin-kerf sawing. The welded bond between stellite and the steel base generally is stronger than the soldered bond between carbide and steel.

3. Stellite tips appear to be less prone to mechanical damage and damage can be repaired more easily.

4. Grinding is somewhat less costly because of cheaper grinding wheels.

5. Low costs of stellite tips. A stellite tip costs 2 to 3 cents only compared to $0.60 to $1.20 for carbide tips.

The time and application costs for carbide and stellite tipping are approximately the same.

EQUIPMENT COSTS FOR STELLITE TIPPING

The price of semi-automatic tipping machines which have been discussed earlier is about $9,500. A recently introduced fully automatic machine costs approximately $30,000, but on the examination of a tipped sample, the tip which is produced is not as well shaped as that obtained with the semi-automatic tipping machine. However, the manufacturer of the automatic machine claims that his machine automatically tempers the blade after tipping by high-frequency heating.

The other required piece of equipment is the side grinder. A side grinder for band saws costs approximately $8,000. For side grinding circular saws, no grinder has to be acquired if a mill already possess a grinder for carbide tipped saws. All that is required is to replace the diamond wheel with a wheel which is suitable for grinding stellite. Where a mill needs a side grinder for circular saws, it either can be acquired separately or as a combination of a band and circular saw grinding machine. The costs of this machine amounts to $9,500 approximately.

The maintenance equipment for stellite-tipped saw blades has a short pay-out period. For instance, in one planer mill in British Columbia, which is equipped with a single band resaw savings in downtime, would pay for the costs for acquiring a tipping machine and side grinder in less than three months.

SUMMARY

Stellite tipping is highly effective in reducing saw tooth wear. In cutting unseasoned softwoods, it is superior to presently available methods for reducing wear, including carbide tipping of saws. Cost savings by stellite tipping are substantial. In most mills, the initial equipment costs are paid for within a very short period.

TABLE 1

Methods for reducing wear of saw teeth and the principle elements constituting the cutting edge

	Elements constituting the cutting edge
Carbide tipping	Tungsten carbide in cobalt matrix
High-frequency hardening	Standard saw steel (for instance: 0.75% C, 0.20% Si, 0.35% Mn, 2.00% Ni)
Stellite tipping	50% cobalt, 30% chromium, and other metals
Hard chromium plating	Chromium
Hard metal coating	Tungsten carbide, titanium carbide and other materials

TABLE 2
Chemical Composition and Hardness of Wear-Resistant Materials Tested

Basis		Chemical Composition (percentage)								Hardness R_C
		Co	Cr	W	C	Ni	Fe	Si	B	
COBALT										
	STELLITE 12	59	29	9	1.8	-	-	-	-	47 - 51
	STELLITE 20	45	33	18	2.5	-	-	-	-	55 - 59
NICKEL										
	DELORO ALLOY 50	-	10	-	0.4	77	4	4	1.5	49 - 52
	DELORO ALLOY 60	-	15	-	0.5	70	4.5	4.5	3	59 - 62

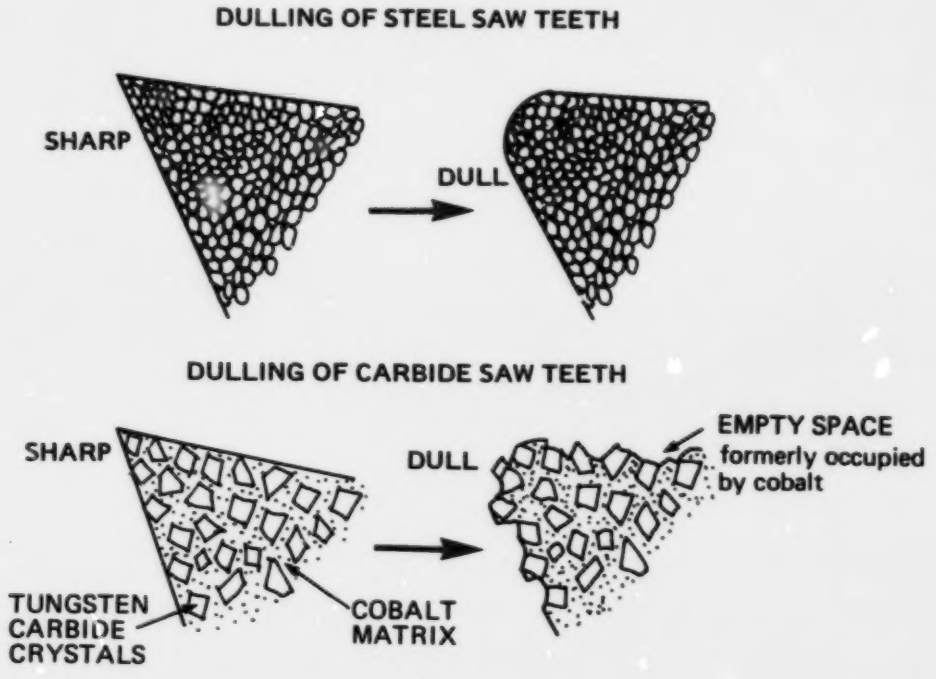

Figure 1. Dulling of saw steel teeth and carbide tips.

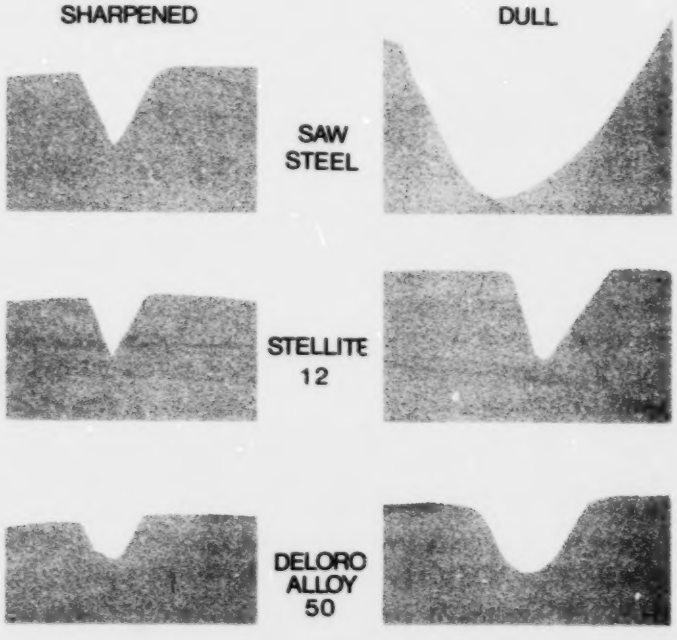

Figure 2. Typical edge profiles of tested materials before and after cutting 35 km or approximately 3 to 4 hours in the sawmill.

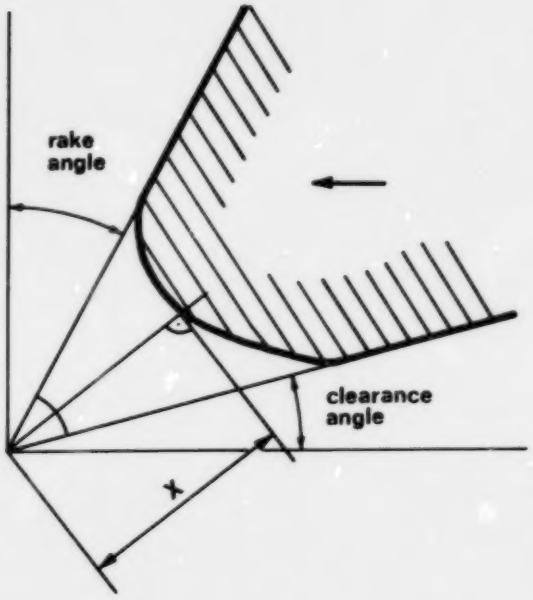

Figure 3. Measurement of cutting edge retreat on saw tooth.

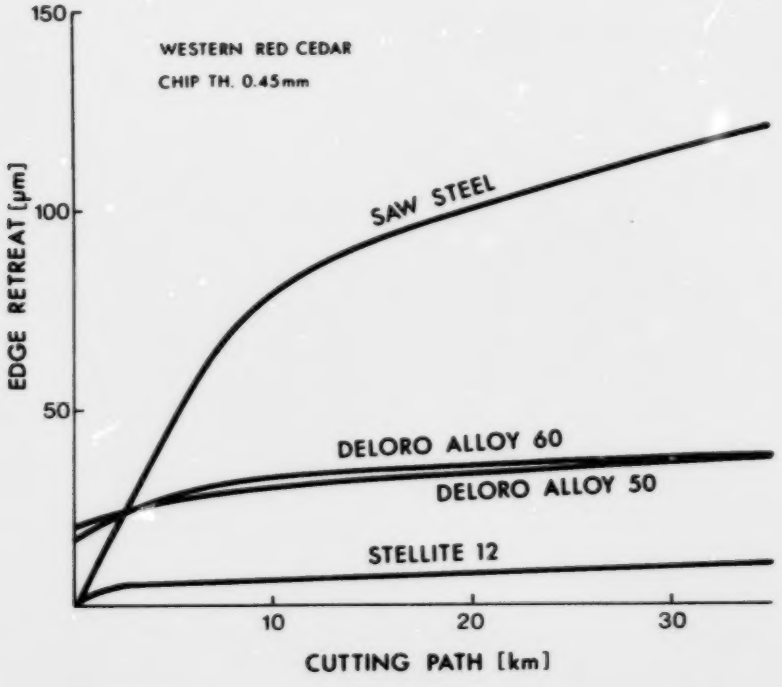

Figure 4. Dulling of standard and tipped saw teeth measured as cutting edge retreat.

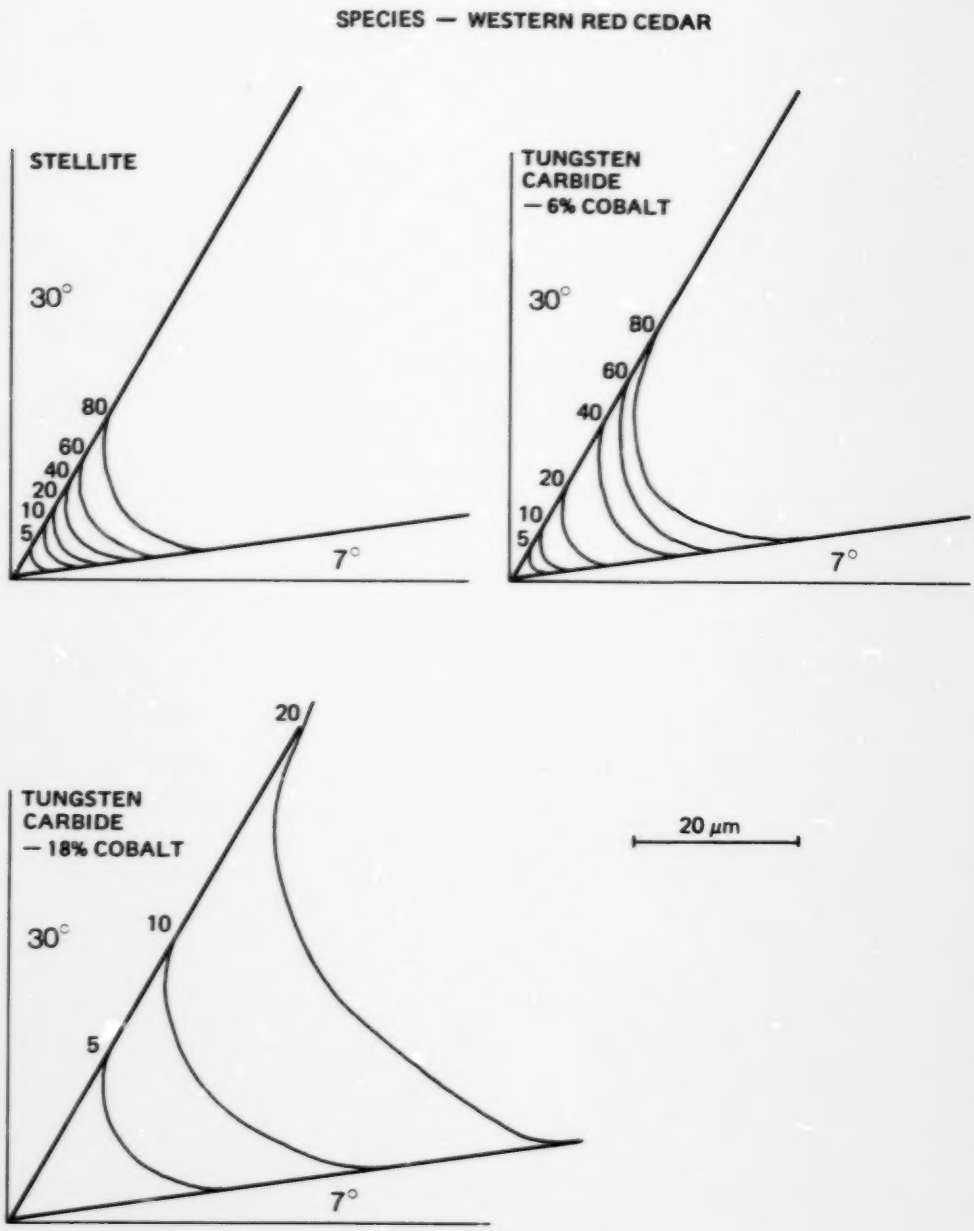

Figure 5. Dulling observed with stellite and two tungsten carbide grades during 80 km or approximately 7 hours of cutting unseasoned western red cedar.

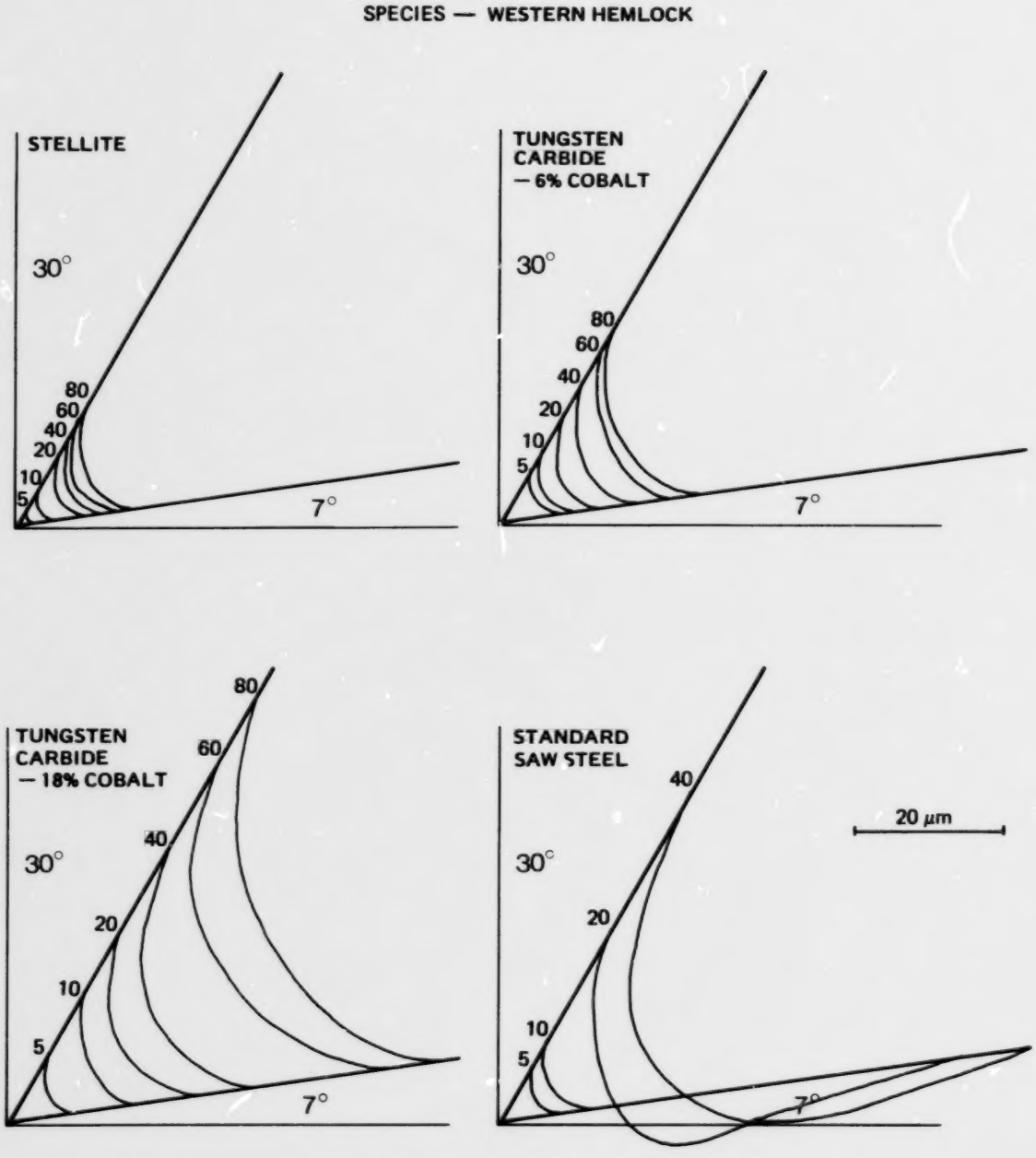

Figure 6. Dulling observed with stellite, two tungsten carbide grades and standard saw steel during 80 km or approximately 7 hours of cutting unseasoned western hemlock.

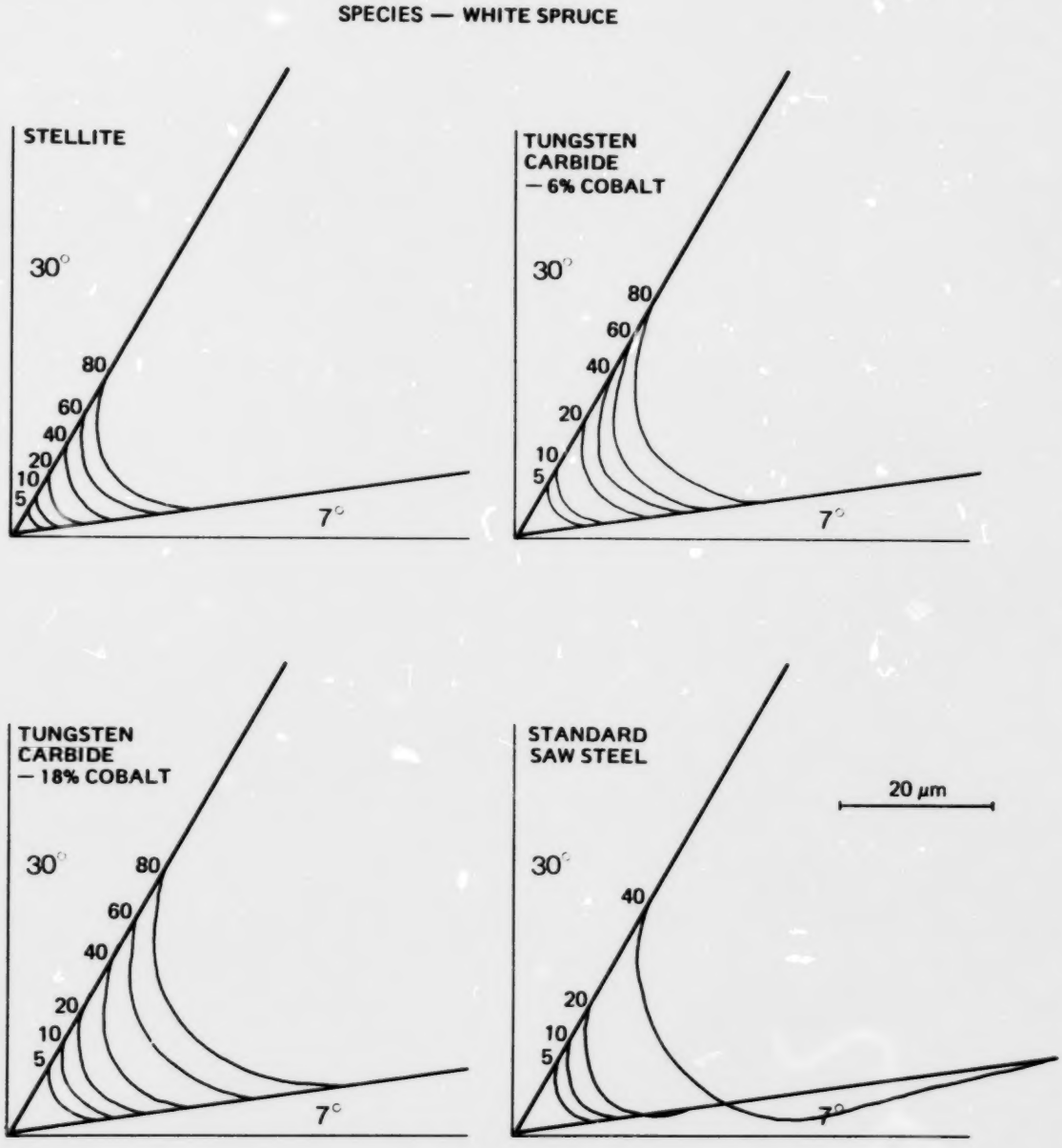

Figure7. Dulling observed with stellite, two tungsten carbide grades and standard saw steel during 80 km or approximately 7 hours of cutting unseasoned white spruce.

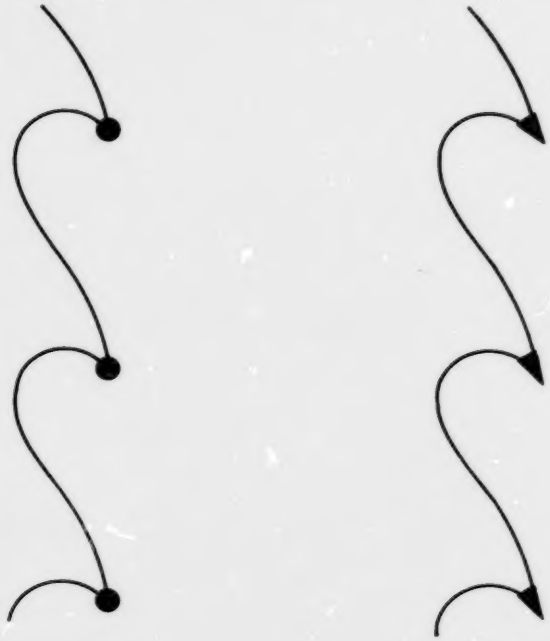

Figure 8. Stellite deposits applied manually (left) and with a stellite tipping machine (right).

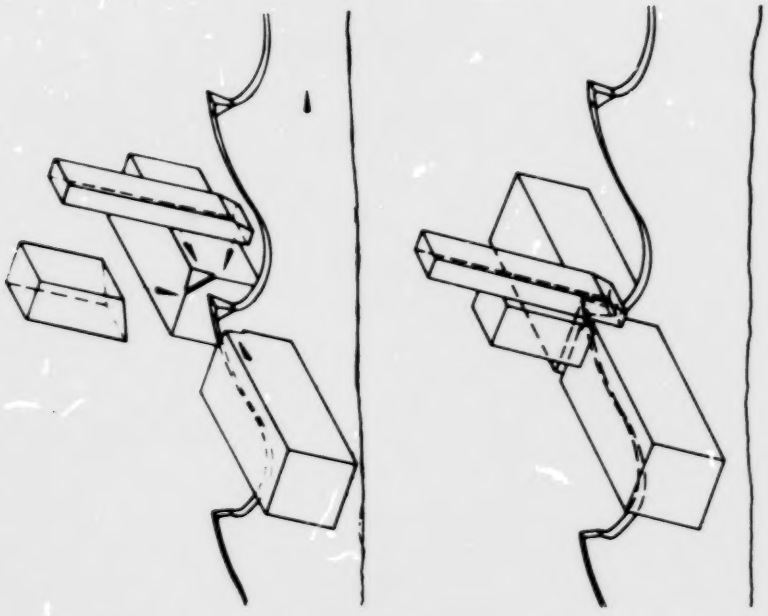

Figure 9. Schematic drawing of a jig which performs the molding action to give the tip the desired geometry.

Figure 10. Close-up picture of a molding jig consisting of four molding jaws.

Figure 11. Deposition of stellite.

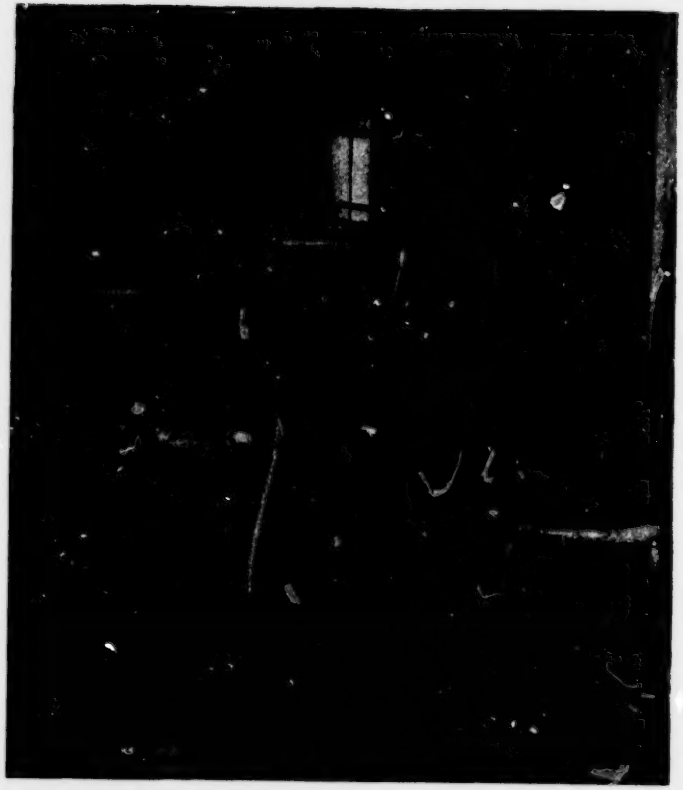

Figure 12. A stellite tipping machine used for tipping both band and circular saws.

Figure 13. The overall view of a stellite tipping machine consisting of tipping unit and stand for holding bandsaw blades for tipping.